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Final Report  
for  
Multifilter Spectrometer (FEB)  
for Microwave Atmospheric Sounder  
Contract No. N00014-86-K-0236

by  
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This report summarizes the work performed under Contract No. N00014-86-K-0236. A summary of the work reported in the previous semi-annual reports is presented first. Then the work performed from October 1987 through the completion of the project is described. The purpose of the research was to develop, in conjunction with Dr. Phil Schwartz of the Naval Research Laboratory (NRL), the multifilter electronics box (FEB) which is part of the Millimeter Atmospheric Sounder, MAS. The MAS observes the earth's atmosphere at five microwave/millimeter-wave frequencies to measure water vapor, ozone, and chlorine-monoxide. This Shuttle-borne experiment is under development by an international team comprised of members from the Institut fur Angewandte Physik (IAP), Bern, Switzerland; the Max-Planck-Institut fur Aeronomie (MPAe), Lindau, Germany, and the Naval Research Laboratory/Penn State University. The FEB provides the detailed spectral analysis of the receiver outputs through the use of 240 separate filters and detectors, whose digitized outputs are passed on to the experiment computer. ←

The joint cooperative effort between Penn State and NRL began several months before the initiation of this contract starting with detailed discussions between NRL and Penn State about the internal mechanical layout of the FEB. We also began to assemble and study the large volume of requirements documents produced by NASA and Dornier Systems, the German aerospace contractor that is providing overall system integration. During October 22-24, 1985, Penn State hosted a Science Meeting of the MAS team. During the next month, more detailed drawings and the first drafts of the EMC analysis and the structural analysis of the mechanical components of the FEB were prepared for a Preliminary Design Review meeting to be held in December. Dr. L. Hale

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surveyed the products of a large number of power supply manufacturers in order to select an appropriate unit for the flight version before choosing Arnold Magnetics, Inc.

The MIL-SPEC connectors were ordered, as well as the elastomer gaskets for the EMC shielding, using funds made available from the College of Engineering. Dr. J. Kiusalaas and his graduate student, A. DiNicola, of the Department of Engineering Science and Mechanics, performed finite-element analysis of the filter card. I developed a finite difference analysis of the temperature distribution across the baseplate and within each filter card. The prints for the filter card containers were received from NRL and a first sample was built using a numerical control program. Since an outer metal enclosure of the whole FEB was needed for the engineering prototype, a custom drawn-metal box from ZERO Corporation was ordered.

Through the next several months, finite-element computer analysis of the baseplate and subassemblies was performed to determine the lowest natural resonant frequency and the resulting mode shapes. A professional quality "configuration drawing" which showed the overall dimensions of the FEB was prepared. The drawn-metal box for the prototype was modified by the PSU machine shop for inclusion of connectors and attachment bolts.

With the arrival of external funds for this project, financial support of the graduate student was begun. The EMC and mechanical analysis reports were updated for submission to NASA during the summer. Construction drawings of the outer box and some of the internal modules were made.

NASA finally reviewed the document submission in August 1986. Appropriate responses to their comments were prepared before a meeting

with the team from Marshall Space Flight Center at a Requirements Review meeting held at Dornier Systems in Friedrichshafen Germany at the end of September. The following week a Critical Design Review meeting was held in Lindau, Germany, where the various team members responded to another series of Discrepancy Notices, primarily from Dornier Systems.

During the fall, several flight items were received and forwarded to NRL. These included the prototype EMC gaskets and the flight power supply. Also delivered to NRL was a prototype filter card eggcrate assembly. Minor modifications of the prints were then made and the numerical-control tapes were changed to accommodate these requested changes. In January 1987 the machine shop production of these filter card support enclosures continued, followed by the production of the corresponding cover plates. Certified analysis material has been used and documentation added for traceability of the production process.

Documentation revision continued to include in the EMC analysis additional information requested by Dornier Systems. Major revisions of the mechanical design analysis report were also done.

In April 1987, MSFC conducted a series of Payload Element Developer Requirements Review meetings for each of the thirteen experiments which will be flying on the ATLAS 1 mission. Of particular interest was a "structures" subgroup meeting at which the differences between the Dornier Systems approach and that of MSFC were resolved. At the end of the week, most of the MAS team visited Penn State for an additional review of our progress.

Because Penn State's in-house machine shop was uncertain whether they could meet the flatness requirement for the bottom plate of the FEB which interfaces thermally to the Shuttle's cold plate, a

speciality house in California was found that could meet the flatness requirement with a dual face flat grinding operation.

Joint meetings with NRL determined the method of attachment of the synthesizers and an overhead deck above the synthesizers to the baseplate. Completion of these drawings was delayed until the layout of the printed circuit board that fits into this deck was completed at NRL. Layout drawings of the internal cross-braces were made.

The finite element mechanical analysis of the FEB structure will eventually have to be supplied as a file compatible with NASTRAN. A survey of commercially available desk-top PC conversion programs that can generate a NASTRAN-compatible output deck has been made.

The mechanical fabrication of the FEB continued with generation of the numerical control tapes for the outer cover and construction proceeded. Another dummy baseplate was constructed and sent to NRL for use in laying out the internal module and cable routings. NRL found that additional IF amplifiers were necessary to overcome excessive insertion loss of the K&L filters. These additional amplifiers have increased the overall power drain on the +15 volt buss. The existing flight hardware DC-DC converter power supply is no longer sufficient and another larger unit has been ordered.

Since the last semi-annual report in October 1987, the following additional work has been completed.

The flight hardware baseplate was subcontracted to a speciality machine shop located in California which was able to meet the stringent flatness requirements. We have also delivered to NRL the five plates that make up the outer cover of the FEB which were fabricated at the Penn State machine shops. Internal mechanical

components such as the power and signal doghouses, power distribution bridge, etc. have also been sent to NRL. The replacement DC-DC converter power supply has not yet been received.

The production drawings of the internal mechanical components have been updated to accommodate changes requested by NRL. The drawing family trees have been expanded to include the drawings produced at NRL. A major revision of three analysis documents has been completed. The EMC Analysis report considers the design requirements needed for proper electromagnetic capability in the Shuttle environment. The FEB lifting analysis considers the mechanical analysis of the strength of the lifting of the complete FEB, either by hand or with an overhead crane and sling. The FEB structure analysis considers both the attachment of the FEB to the coldplate support structure of the Shuttle and the attachment of the internal modules to the baseplate of the FEB itself. Additional finite element analysis computer runs were performed to determine the mechanical resonant frequencies and modes of vibration for the internal structure of the FEB. These reports are part of the documentation package which has been sent to NASA at Marshall Space Flight Center. They will be discussed at the PED meeting held with NASA at Friedrichshafen, Germany, in mid-March.

The technical reports produced under this grant are:

TN 2036-1310 NR/01, FEB Structural Analysis

TN 2036-9810 NR/01, FEB Lifting Device Analysis

TN 2036-1310 NR/03, EMC Analysis of the MAS-FEB